

## CLAIMS

1. A lithographic projection apparatus comprising:
  - 5 an illumination system for supplying a projection beam of radiation;
  - a first object table for holding patterning means capable of patterning the projection beam according to a desired pattern;
  - a second object table for holding a substrate having a surface to be exposed, such that, when held on the table, the said surface lies in a reference plane;
  - 10 a projection system for imaging the patterned beam onto a target portion of the substrate; and
  - a positioning system for moving said second object table between an exposure position, at which said projection system can image said patterned beam onto said substrate, and a measurement position; characterized by:
    - 15 a calibration system for measuring lateral displacements of a reference point in a plane of said second object table as a function of tilt, at said measurement position, wherein said calibration system comprises:
      - a diffraction grating mounted to said second object table;
      - illuminating means for generating a measurement beam of radiation and directing it to
      - 20 be incident on said diffraction grating so as to be diffracted thereby; and
      - a detector for detecting the position of said diffraction grating.
2. Apparatus according to claim 1 wherein said diffraction grating is an at least partially transmissive diffraction grating and said calibration system comprises a light guide for
- 25 directing said measurement beam to be incident on said diffraction grating in a direction substantially independent of the tilt of said second object table.
3. Apparatus according to claim 1 or 2, wherein said calibration system is constructed and arranged for measuring displacements of a reference point in said reference plane and said
- 30 diffraction grating is mounted substantially parallel to said reference plane on said second object table.
4. Apparatus according to claim 2 or 3, wherein said illuminating means is arranged to emit said measurement beam along an incident path substantially perpendicular to and spaced
- 35 from said diffraction grating, and said light guide comprises a plurality of reflectors mounted

to said second object table behind said diffraction grating relative to said illuminating means and positioned to reflect said measurement beam onto a return path parallel to said incident path and passing through said diffraction grating in a direction opposite to said incident path.

- 5      5.      Apparatus according to claim 4, wherein said plurality of reflectors comprises a transparent body having three mutually perpendicular faces at which said measurement beam undergoes reflection.
- 10      6.      Apparatus according to claim 1, 2 or 3, wherein said illuminating means is arranged to emit said measurement beam along an incident path substantially perpendicular to said diffraction grating and passing therethrough, and said light guide comprises a retro-reflector mounted to said second object table behind said diffraction grating relative to said illuminating means for reflecting said measurement beam along a return path substantially parallel to said incident path and passing back through said diffraction grating.
- 15      7.      Apparatus according to claim 6, wherein said retro-reflector comprises a plane-reflector and a condensing lens mounted at a distance substantially equal to its focal length from said plane-reflector.
- 20      8.      Apparatus according to claim 7, wherein said retro-reflector comprises a solid body of transparent material having a front surface curved to form said condensing lens and a plane rear surface partly reflective to form said plane-reflector.
- 25      9.      Apparatus according to claim 7 or 8, wherein said plane-reflector is sized and positioned so as to reflect substantially only the zeroth diffraction order of the measurement beam diffracted by its first passage through said diffraction grating.
- 30      10.     Apparatus according to claim 9, further comprising absorbent or diffusive surfaces in the plane of said plane-reflector outside the reflecting area thereof.
- 35      11.     Apparatus according to claim 6, wherein said retro-reflector comprises a corner-cube.
12.     Apparatus according to any one of claims 6 to 11 further comprising an anti-reflection coating on at least one surface of said diffraction grating.

13. Apparatus according to any one of the preceding claims comprising a plurality of calibration systems for measuring displacements of said second object table with tilt about a plurality of axes.

- 5 14. A method of calibrating a lithographic projection apparatus comprising:  
an illumination system for supplying a projection beam of radiation;  
a first object table for holding patterning means capable of patterning the projection  
beam according to a desired pattern;  
a second object table for holding a substrate having a surface to be exposed, such that,  
10 when held on the table, the said surface lies in a reference plane;  
a projection system for imaging the patterned beam onto a target portion of the  
substrate; and  
a positioning system for moving said second object table between an exposure  
position, at which said projection system can image said patterned beam onto said substrate,  
15 and a measurement position, said positioning system including electronic control means  
having parameters defining a rotation-invariant point of the second object table; the method  
comprising the steps of:  
measuring the position of a reference point on the surface of the second object table  
at different tilts;  
20 calculating the distance between the surface of the second object table and a rotation-  
invariant point of the second object table;  
adjusting parameters of said electronic control means included in said positioning  
system so that said rotation-invariant point is at a predetermined vertical distance from the  
reference surface of the second object table.

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15. A method of manufacturing a device using a lithographic projection apparatus  
comprising:  
an illumination system for supplying a projection beam of radiation;  
a first object table for holding patterning means capable of patterning the projection  
30 beam according to a desired pattern;  
a second object table for holding a substrate having a surface to be exposed, such that,  
when held on the table, the said surface lies in a reference plane;  
a projection system for imaging the patterned beam onto a target portion of the  
substrate; the method comprising the steps of:  
35 providing a substrate provided with a radiation-sensitive layer to said second object

table;

providing a projection beam of radiation using the illumination system;

using said patterning means to endow the projection beam with a pattern in its cross section; and

- 5 moving the second object table to an exposure position, and projecting the patterned beam of radiation onto said target portions of the substrate; characterized by the step of:
- detecting displacements of a reference point of said second object table at various angles of tilt when situated at said measurement position.

- 10 16. A device manufactured according to the method of claim 16.